Space Weather Technical Forecast

Issued on Wednesday 9 October 2024 at 13:28 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of X-class flares. Ongoing S2/Moderate Solar Radiation Storm, chance of S3/Strong Solar Radiation Storm until day 3. G1-G2 Minor/Moderate storms expected, chance of G3/Strong storms and slight chance of G4/Severe storms days 2 and 3.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity has been at High levels with an X1.8 flare peaking at 09/0156 UTC from AR3848. There are currently five numbered sunspot regions visible. AR3842 is now in it's transit around the limb and therefore it's previous classification is preserved, with a delta present. AR3848 in the north-centre has a large mature positive leader, with numerous small trailing spots and weak penumbra surrounding them, one spot is of opposite polarity and connected to the leader therefore classified as a delta region. AR3849 and AR3850 remain very close to each other. The more westward spot, AR3849, appears to be reducing in size and is simplifying, whereas AR3950 is much larger now with a delta spot present in the compact central region. AR3852 in the southeast appears to have slightly reduced in area, with a small decay in penumbra around intermediate spots. The two new regions reman small and unnumbered.

A large material-rich full halo CME was observed leaving the Sun in association with the X1.8 flare and filament eruption early on 09 Oct. This CME has been analysed as arriving at Earth late 10 or early 11 Oct.

Solar Wind / Geomagnetic Activity: The period was indicative of waning CME and coronal hole high speed stream influence. Solar wind speed remained slightly elevated, mainly between 400-500km/s, with density varying between below average and average values. Interplanetary Magnetic Field, Bt, was initially Moderate at 8-12nT, but gradually declined to Weak levels, ending the period at 5nT. The north-south component, Bz, favoured a negative (southward) orientation with fluctuations between +7 to -10 nT, with only brief spells of positive (northward), on a weakening trend. Phi angle was positive (away from the Sun). Geomagnetic activity was Unsettled to Active (Kp 3-4) with one G1/Minor storm (Kp 5) period.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 was initially slightly raised, but then decreased to background levels, before responding to the X1.8 flare on 09 Oct, rising to S2/Moderate storm levels, reaching 844 pfu at 09/1210 UTC. High energy electron flux (greater than 2MeV) observed by GOES16 was at predominantly at

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background levels, but temporarily reached Moderate levels of 223 pfu at 09/0945 UTC. The associated 24-hour fluence was below the Active threshold with 1.16e6 observed at 09/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is expected, with a chance of further isolated X-class flares until day 3 (11 Oct). From then activity is then expected to decrease Low to Moderate, but with a slight chance of X-class flares.

Solar Wind / Geomagnetic Activity: There are two CMEs which may glance Earth early day 2 (10 Oct). A large full halo CME is then expected to arrive at Earth late day 2 or early day 3 (10/11 Oct) Oct.

Solar winds are slightly elevated, with a slight chance of increasing to 500-550 km/s should any of the glancing CMEs have peripheral impacts at Earth from early day 2 (10 Oct). Late on day 2 (10 Oct) or more likely early day 3 (11 Oct), the full halo CME is expected to arrive, perhaps increasing wind speeds to 600-700km/s. Solar wind speeds should then begin to ease back to slightly elevated (400-500 km/s) by day 4.

Geomagnetic activity is expected to be Unsettled to Active (Kp 3-4) initially with a chance of isolated G1/Minor storms (Kp 5) due to either residual CME/CH HSS effects or glancing CMEs early day 2 (10 Oct). Activity is then expected to increase later day 2 or early day 3 (10/11 Oct) due to the arrival of the full halo CME, bringing likely G1-G2/Minor-Moderate storms (Kp 5-6), a chance of G3/Strong storms (Kp 7) and a slight chance of G4/Severe storms (Kp 8), more weighted to day 3 (11 Oct). By day 4 (12 Oct) geomagnetic activity should begin to decline, becoming predominantly Quiet to Active (Kp 2-4), but with a chance of G1/Minor Storms (Kp 5), due to any residual CME effects.

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 is currently at S2/Moderate storm levels with a chance of rising above S3/Strong storm levels due to a response from a combined X1.8 and filament eruption on 09 Oct. Similar conditions are expected 10 Oct before easing from 11 Oct. High energy electron flux may reach diurnally Moderate of High in coming days but will likely be suppressed from 11 Oct onward due to CME interactions. The associated 24 hour election fluence is expected to remain below the Active threshold (1e8 total pfu).

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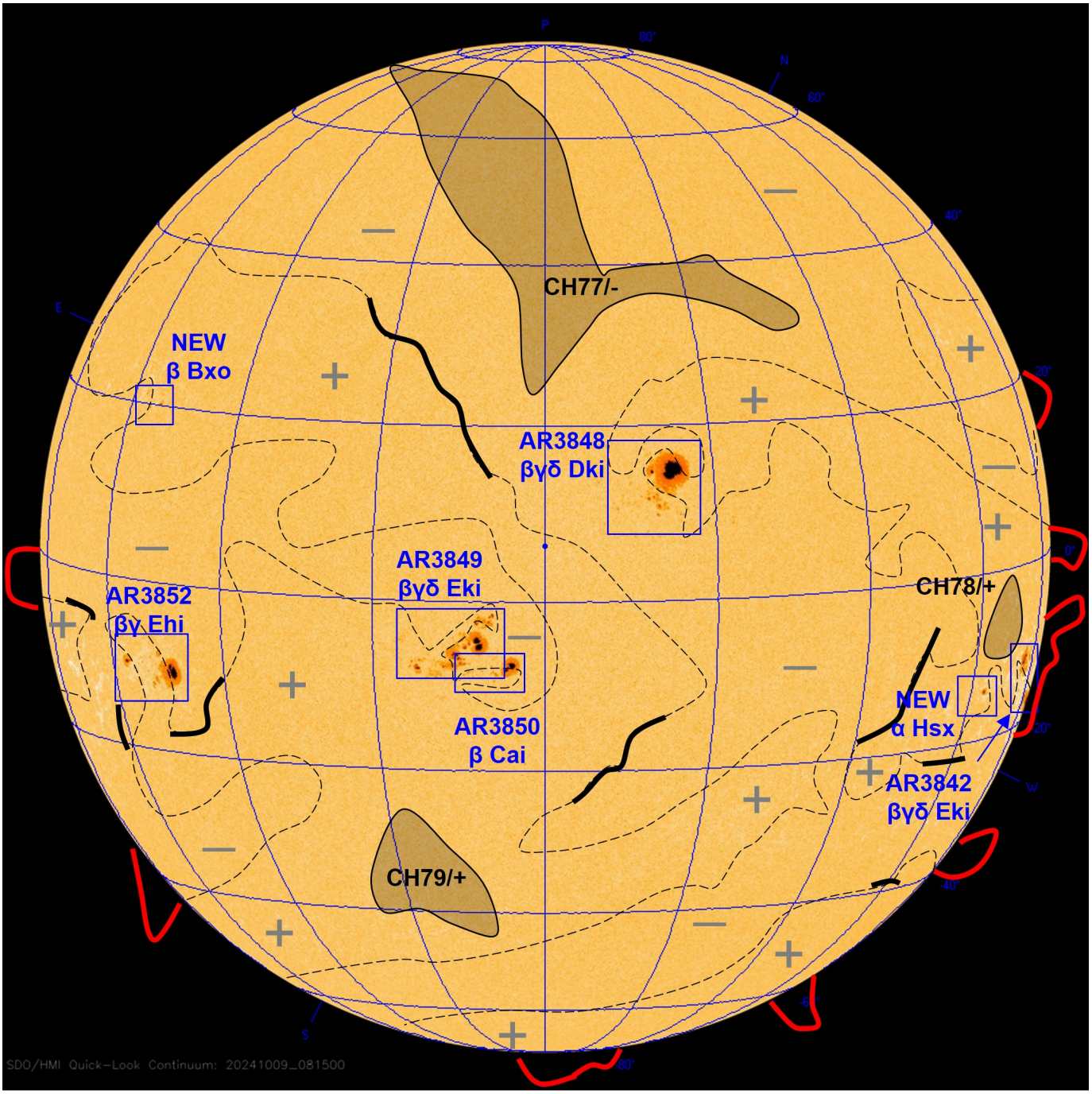
Figure 1: Solar synoptic map valid 09/0800 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

The large and bright CMEs evident from the X2.1 and X1.0 flares are expected to miss Earth but may have an outside chance of glancing impacts, perhaps on day 2 (10 Oct). A large filament eruption was also seen to leave the Sun early on 08 Oct, it appears to be mostly south directed, but a weak glancing blow from the associated CME is possible also the 10th or 11th. A large material-rich full halo CME was observed leaving the Sun in association with the X1.8 flare and filament eruption early on 09 Oct. This CME has been analysed as arriving at Earth late 10 or early 11 Oct, bringing potentially strong solar winds for a time.

The solar wind environment around Earth has returned back to largely background conditions, though solar wind speeds remain slightly elevated. Similar conditions are expected though day 1 and into day 2 (09-10 Oct) with a slight chance of increasing to 500-550 km/s should any of the glancing CMEs have peripheral impacts at Earth from early day 2 (10 Oct). Late on day 2 (10 Oct) or more likely early day 3 (11 Oct), the full halo CME is expected to arrive, perhaps increasing wind speeds to 600-700km/s for a number of hours. Solar wind speeds should then begin to ease back to slightly elevated (400-500 km/s) by day 4.

Geomagnetic activity is expected to be Unsettled to Active (Kp 3-4) initially with a chance of isolated G1/Minor storms (Kp 5) due to either residual CME/CH HSS effects or glancing CMEs early day 2 (10 Oct). Activity is then expected to increase later day 2 or early day 3 (10/11 Oct) due to the arrival of the full halo CME, bringing likely G1-G2/Minor-Moderate storms (Kp 5-6), a chance of G3/Strong storms (Kp 7) and a slight chance of G4/Severe storms (Kp 8), more weighted to day 3 (11 Oct). By day 4 (12 Oct) geomagnetic activity should begin to decline, becoming predominantly Quiet to Active (Kp 2-4), but with a chance of G1/Minor Storms (Kp 5), due to any residual CME effects.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	Yes	30	70	80	60
Strong	**G3**	No	1	30	40	20
Severe	**G4**	No	1	10	20	1
Extreme	**G5**	No	1	1	2	1

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Figure 2: MOSWOC Enlil showing 09 Oct CME arrival.

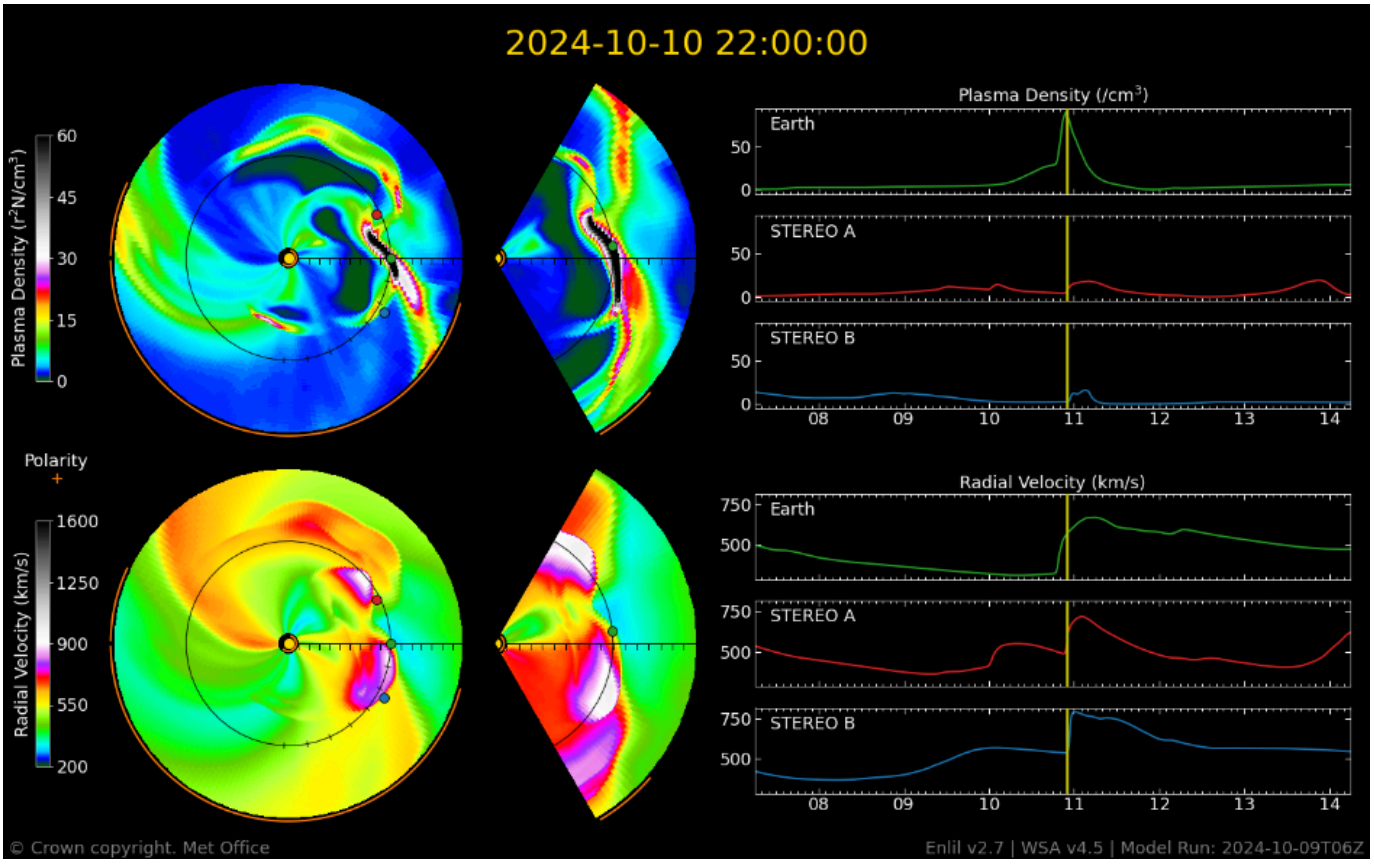
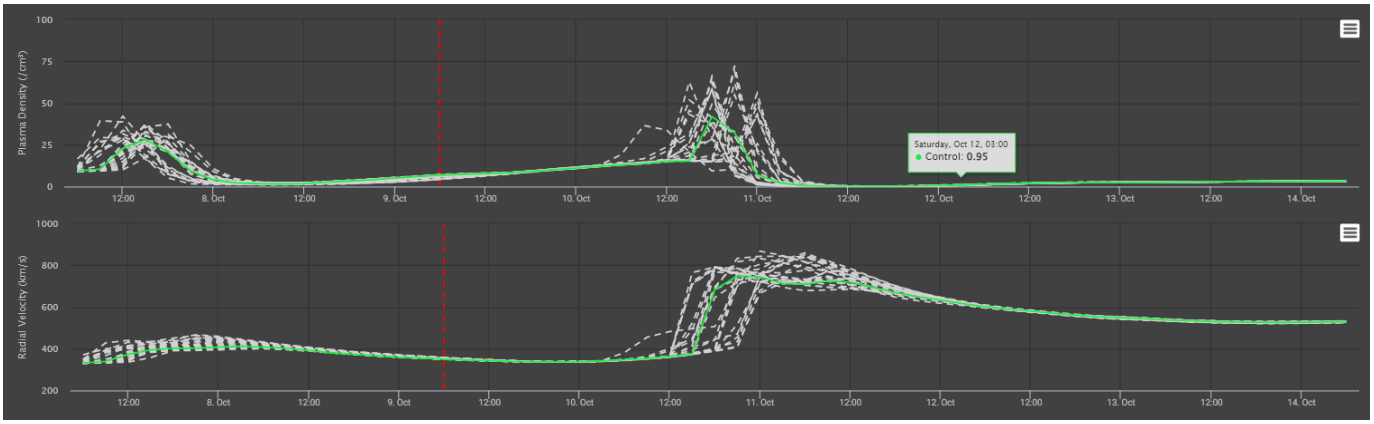


Figure 3: MOSWOC Enlil ensemble.



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Radio Blackouts - X-Ray Flares

Activity has been at High levels with an X1.8 flare peaking at 09/0156 UTC from AR3848.

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There is an ongoing chance of isolated X-class flares, from any of the three regions with delta spots. As AR3842 rotates around the limb on day 2 (10 Oct) and continues this trajectory day 3 (11 Oct), there is a decreasing risk of flares in the next 3 days.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	80	70	60	60
Very Active	R3-R5 (X Class)	Yes	40	30	20	20

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Figure 4: 24 hour X-ray trace

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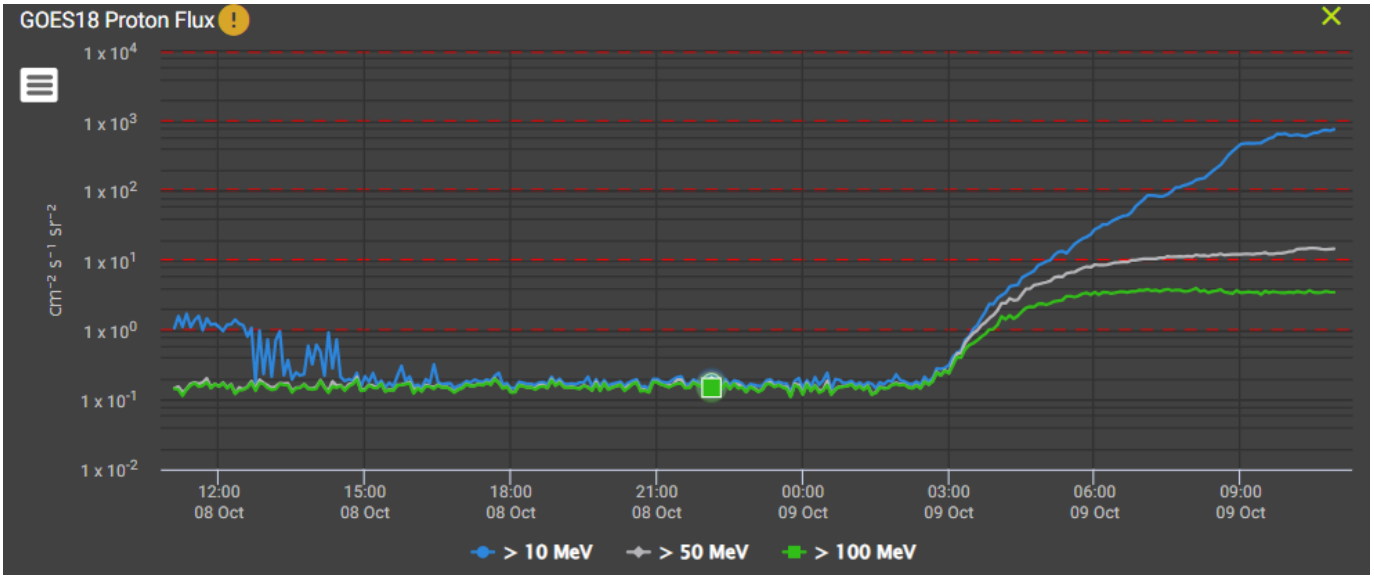
Solar Radiation Storms (High Energy Protons)

High energy proton flux at GOES18 has responded to the X1.8 flare and associated filament eruption that occurred early on 09 Oct, with proton levels rising above S2 Moderate storm levels. S1-S2 Minor-Moderate Proton storms are expected for the remainder of day 1 and into day 2 (09/10 Oct) with a chance of reaching S3 Strong storm levels each day, with a decreasing trend thereafter. There remains a chance of further enhancement given both AR3842 and AR3848 remain in favourable locations should any further notable flares occur.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	90	30	20
Very Active	**≥ S3 ***	No	50	30	5	5
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: 24 hour proton trace



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High Energy Electrons (≥ 2MeV)

High energy electron flux (greater than 2MeV) observed by GOES16 has been at background levels with little response since the easing of the geomagnetic activity associated with the CME and CG HSS arrivals. The combination of both was thought to have increased electron populations at lower orbits. As solar wind pressure continues to subside and the Van Allen belts return outward, there remains a chance of flux to rise at GEO. On the contrary the CME may have acted like a snow-plough to clear out part of the electron population. Diurnal Moderate or High flux levels are possible through 09 and 10 Oct before the CME from 09 Oct arrives by 11 Oct and once again clears or supresses the electron population.

The associated 24 hour fluence is expected to persist below the Active (1e8 total pfu) threshold, but with a slight chance of rising above on 10 or early 11 Oct before the CME arrives.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ 1×10^{8}**	No	1	10	10	1
Very Active	**≥ 2 MeV ≥ 1×10^{9}**	No	1	1	1	1

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Figure 6: Electron flux (top) and MOSWOC REFM fluence forecast/observations/recurrence (bottom)

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